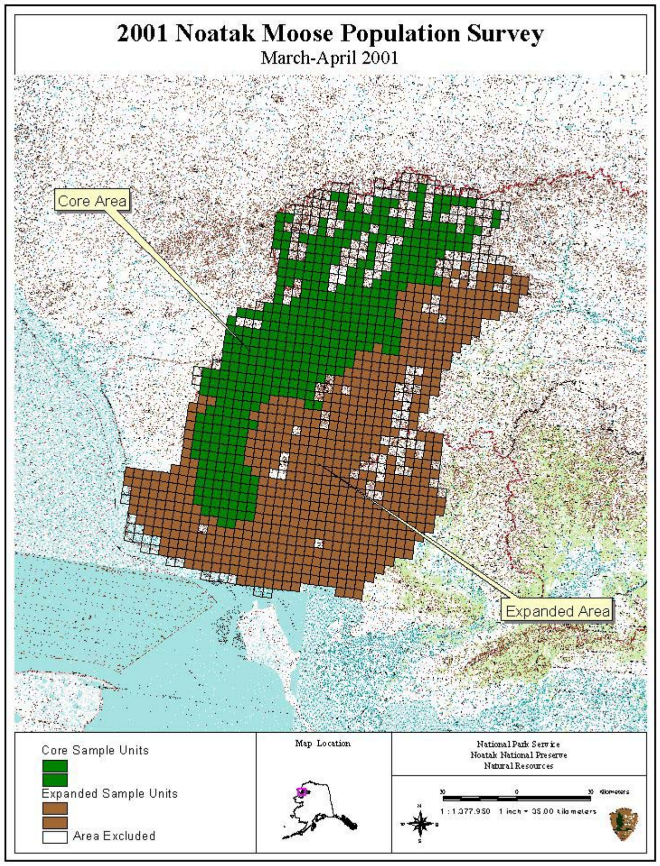
NOATAK MOOSE POPULATION SURVEY
NOATAK NATIONAL PRESERVE
MARCH-APRIL 2001



SUMMARY FILE REPORT
NATIONAL PARK SERVICE
WESTERN ARCTIC NATIONAL PARKLANDS
AUGUST 2001

2001 Noatak Spring Moose Survey[1]

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INTRODUCTION

A moose population survey was completed in the middle and lower Noatak River area during late March and early April. The survey was conducted by the Alaska Department of Fish and Game (ADF&G) with financial support from the Western Arctic National Parklands and personnel support from the Selawik National Wildlife Refuge.

The objectives of the survey were:
1) To estimate the abundance of moose
2) To determine calf recruitment
3) To compare density of moose between "core" and "expanded" survey areas

SURVEY AREA

The Expanded, Spring survey area covered 5,230 mi^2 (13,546 km^2) and consisted of 421 "core" and 610 "expanded" sample units (Figure 1). Survey units were square with a mean area of 5.1 mi^2 (13.2 km^2). The "core" area includes sample units delineated for the Autumn 1993 Noatak River moose survey that encompass the Kelly, Kuguroruk, and Noatak Rivers. Based upon radiotelemetry locations and movements of radiocollared moose collected since 1992, the core survey area was expanded for this survey to include additional habitat that better represented the range of the radiocollared population. The result was an "expanded" area that included sample units encompassing Noatak Village to the south, the southern half of Cape Krusenstern National Monument, and the western portion of the Squirrel River valley. The Expanded, Spring Survey Area includes the combined area of the core and expanded sample units. Data are presented separately for the core and expanded areas as well as the combined expanded, spring survey area.

SURVEY METHODS

Survey methods followed the protocols for the "spatial technique" described by Jay VerHoef of the ADF&G (Appendix A). The survey results were analyzed by Jay VerHoef and Jim Dau.

The survey area was stratified as high and low moose density units based on historical knowledge and visual observations (i.e. no stratification flights were completed). The ADF&G, Unit 23-Wildlife Biologist conducted presurvey reconnaissance flights to determine the reliability of "desktop" stratification prior to the survey and to determine if snow conditions would permit a reasonable sightability for moose.

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[1] Results compiled from data provided by Jim Dau, ADF&G

RESULTS and DISCUSSION

Stratification resulted in over 80% of sample units being classified as low density (Table 1 and Fig. 2). The expanded area had the highest proportion (i.e. 95%) of low density units (Table 1 and Fig. 2).

Only 16% of the total survey area was sampled, and 626 moose were observed (Table 2). Over 88% of moose were observed in the core area sample units. Sample unit data are presented for core and expanded units separately (Tables 3 and 4). Estimated moose density in the core area was the same as measured in 1993 (Table 5). Density was lowest in the expanded area and contributed to the overall low density estimated for the entire survey area (Table 2). Despite the agreement of density estimates between 1993 and 2001, low calf recruitment (i.e. ≤ 10 : 100 adults) during the last several years (Table 5), and high adult mortality (i.e. ≥ 15 %)(unpubl. data) indicate that the population is most likely declining at a slow rate. Density of moose will likely remain at or below 1 moose/mi^2 over the long-term since predator numbers remain high, and winter snowfall has been above average for 10 of the last 13 years showing a trend toward more severe winters (National Weather Service, unpubl. data).

Calf recruitment was estimated to be 7-12 calves : 100 adults (Table 2), and is below the value needed to offset the estimated adult mortality. Spring productivity surveys during May 1998 and 1999 indicate that calf mortality rates are between 60-75% during the first month (unpubl. data). Although pregnancy and twinning rates are normal (i.e. 90%+ and 40%, respectively), neonatal and overwinter survival rates are low presumably from predation, especially grizzly bears and wolves, respectively (unpubl. data).

Table 1. Survey area characteristics for the Noatak River moose survey area, Spring 2001.

	Survey Area		
	Core	**Expanded**	**Spring, Expanded**
Area (mi^2)	2,111	3,119	5,230
No. of Sample Units	421	610	1,031
High Density	143 *(34%)*	31 *(5%)*	174 *(17%)*
Low Density	278 *(66%)*	571*(95%)*	857*(83%)*
Area Surveyed (mi^2)	572 *(27%)*	260 *(8%)*	832 *(16%)*

Table 2. Moose population estimates, number of moose observed, and recruitment estimates, Noatak River, Spring 2001.

	Core	Expanded	Spring Expanded
Spatial Population Estimate *(80% CI)*	1,407 *(1,237-1,578)*	324 *(189-458)*	1,731 *(1,486-1,976)*
No. of Moose Observed	626	83	709
Moose (Density Estimated) (moose/mi^2)	0.7	0.1	0.3
Moose Density (Observed)	1.1	0.3	0.9
Short Yearling : 100Adult Ratio *(80% CI)*	9 *(7-11)*	11 *(2-19)*	10 *(7-12)*
No. of Calves Observed	6	47	53

Table 3. Sample unit data from the “core” survey area that includes the Autumn and Spring sample units.

Sample Unit	Survey Area[a]	Area (mi^2)	Stratum	Calf	Adult	Total
22	F	4.899	L	0	0	0
26	F	4.899	L	0	0	0
34	F	4.906	L	0	0	0
46	F	4.906	H	2	3	5
58	F	4.913	L	0	0	0
63	F	4.913	L	0	0	0
67	F	4.913	H	0	17	17
73	F	4.913	L	0	0	0
83	F	4.920	H	0	1	1
91	F	4.920	H	2	7	9
92	F	4.920	H	1	21	22
94	F	4.920	L	0	0	0
101	F	4.927	L	0	0	0
108	F	4.927	L	0	0	0
109	F	4.927	H	0	0	0
114	F	4.927	L	0	0	0
119	F	4.927	L	0	0	0
121	F	4.927	L	0	0	0
133	F	4.935	L	0	0	0
142	F	4.935	L	0	0	0
146	F	4.935	L	0	0	0
157	F	4.942	L	0	0	0
187	F	4.950	L	0	0	0
192	F	4.950	L	0	0	0
205	F	4.956	L	0	0	0
209	F	4.956	H	0	0	0
210	F	4.956	H	0	0	0
211	F	4.956	L	0	0	0
252	F	4.963	L	0	0	0
265	F	4.971	H	0	0	0
272	F	4.971	L	0	0	0
274	F	4.971	H	0	2	2
275	F	4.971	H	0	0	0
303	F	4.978	H	0	0	0
324	F	4.985	L	0	0	0
325	F	4.985	L	0	0	0
328	F	4.985	L	0	0	0
329	F	4.985	H	0	1	1
348	F	4.992	H	0	1	1
351	F	4.992	L	2	10	12
355	F	4.992	H	0	15	15

Table 3. Cont.

Sample Unit	Survey Area[a]	Area (mi^2)	Stratum	Calf	Adult	Total
357	F	4.992	L	0	0	0
370	F	4.999	H	0	0	0
371	F	4.999	H	0	0	0
375	F	4.999	H	1	21	22
380	F	4.999	H	0	1	1
384	F	4.999	H	1	3	4
398	F	5.006	H	0	0	0
404	F	5.006	H	0	3	3
411	F	5.006	H	0	4	4
422	F	5.014	L	0	0	0
426	F	5.014	H	0	0	0
427	F	5.014	H	0	2	2
429	F	5.014	L	0	0	0
434	F	5.014	H	1	16	17
435	F	5.014	H	0	7	7
440	F	5.014	L	0	0	0
452	F	5.021	L	0	0	0
454	F	5.021	H	0	6	6
455	F	5.021	H	1	18	19
456	F	5.021	H	0	12	12
457	F	5.021	H	1	14	15
462	F	5.021	L	0	2	2
465	F	5.021	L	0	0	0
475	F	5.028	L	0	0	0
480	F	5.028	H	1	9	10
481	F	5.028	H	0	28	28
482	F	5.028	H	0	0	0
485	F	5.028	L	0	2	2
488	F	5.028	L	0	0	0
501	F	5.035	L	0	0	0
504	F	5.035	H	0	1	1
533	F	5.042	L	0	0	0
539	F	5.042	L	0	1	1
555	F	5.049	H	0	16	16
562	F	5.049	L	1	2	3
578	F	5.058	L	0	0	0
583	F	5.058	H	2	14	16
589	F	5.058	L	0	0	0
590	F	5.058	L	0	0	0
609	F	5.064	H	0	7	7
611	F	5.064	H	0	0	0
614	F	5.064	H	1	2	3
616	F	5.064	H	0	1	1

Table 3. Cont.

Sample Unit	Survey Area[a]	Area (mi^2)	Stratum	Calf	Adult	Total
617	F	5.064	H	1	7	8
635	F	5.071	H	0	7	7
638	F	5.071	H	0	2	2
658	F	5.078	L	0	1	1
659	F	5.078	H	0	7	7
661	F	5.078	H	0	17	17
685	F	5.085	H	0	7	7
711	S	5.092	L	0	0	0
714	S	5.092	H	1	19	20
715	S	5.092	H	0	16	16
716	S	5.092	H	0	3	3
771	S	5.107	H	3	5	8
772	S	5.107	H	2	38	40
773	S	5.107	H	1	5	6
774	S	5.107	L	0	0	0
800	S	5.114	H	5	43	48
801	S	5.114	H	0	15	15
802	S	5.114	L	0	0	0
828	S	5.121	H	3	25	28
829	S	5.121	H	3	41	44
830	S	5.121	H	0	10	10
831	S	5.121	L	0	0	0
890	S	5.135	H	0	0	0
894	S	5.135	L	0	0	0
926	S	5.142	H	0	7	7
960	S	5.150	L	0	0	0
963	S	5.150	H	9	27	36
1000	S	5.157	H	2	7	9
1001	S	5.157	H	0	0	0
1066	S	5.171	L	0	0	0

[a] F=Fall Abundance Survey Area sample unit; S=sample unit is only included in the Spring Abundance/Recruitment Survey Area

Table 4. Count data for the "expanded" area sample units only.

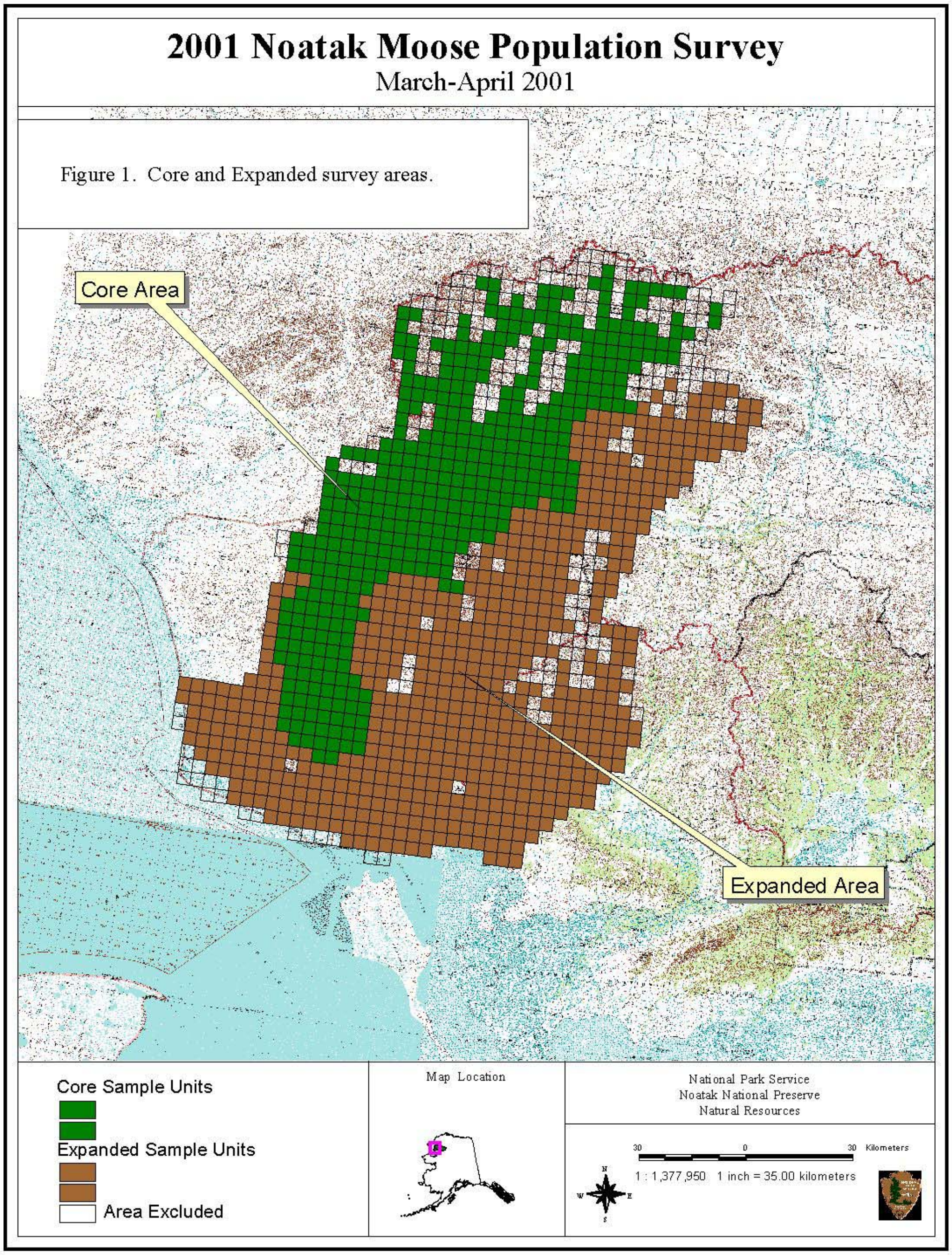
Sample Unit	Stratum	Area (mi^2)	Calf	Adult	Total
198	L	4.950	0	0	0
261	L	4.963	0	0	0
286	L	4.971	0	0	0
306	L	4.978	0	0	0
367	H	4.992	0	0	0
386	H	4.999	0	2	2
388	H	4.999	0	0	0
414	L	5.006	0	0	0
417	H	5.006	0	0	0
444	L	5.014	0	1	1
445	H	5.014	0	2	2
446	H	5.014	2	1	3
447	H	5.014	0	0	0
492	L	5.028	0	0	0
550	L	5.042	0	0	0
593	H	5.058	0	2	2
619	H	5.064	0	3	3
620	H	5.064	0	14	14
645	H	5.071	1	17	18
675	L	5.078	0	0	0
691	L	5.085	0	0	0
709	L	5.085	0	0	0
728	L	5.092	0	0	0
755	H	5.100	1	8	9
768	L	5.107	0	0	0
783	H	5.107	0	8	8
805	L	5.114	0	3	3
811	H	5.114	0	4	4
812	H	5.114	0	1	1
813	H	5.114	0	0	0
823	L	5.114	0	1	1
824	L	5.114	0	0	0
917	L	5.142	0	0	0
934	L	5.142	0	0	0
947	L	5.142	0	2	2
984	L	5.150	0	0	0
1058	L	5.171	0	0	0
1077	L	5.171	0	0	0
1108	L	5.178	0	0	0
1110	L	5.178	0	0	0
1133	H	5.185	0	2	2
1135	H	5.185	1	3	4

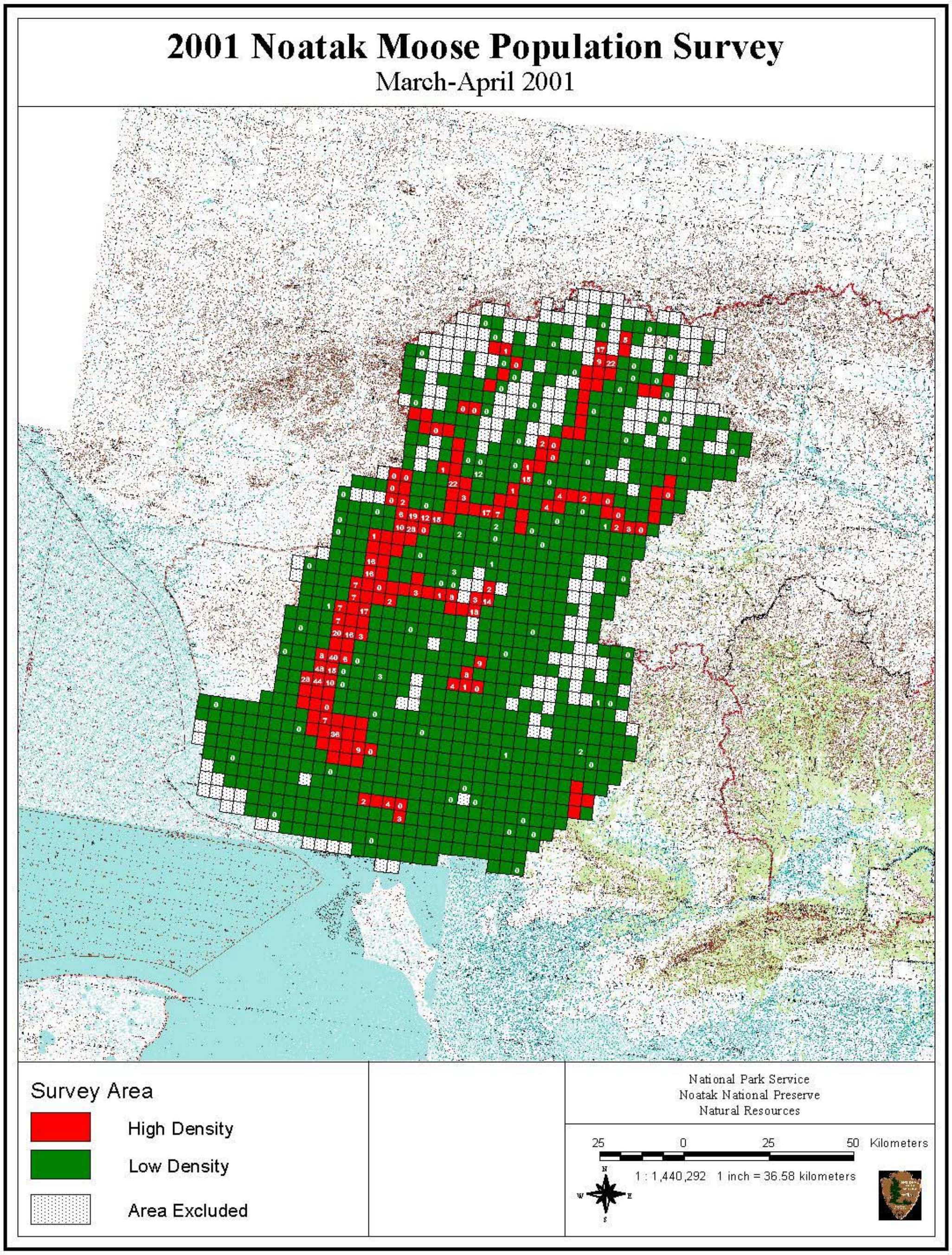
Table 4. Cont.

Sample Unit	Stratum	Area (mi^2)	Calf	Adult	Total
1136	H	5.185	0	0	0
1146	L	5.185	0	0	0
1166	H	5.192	1	2	3
1175	L	5.192	0	0	0
1177	L	5.192	0	0	0
1183	L	5.200	0	0	0
1214	L	5.207	0	0	0
1240	L	5.214	0	0	0

Table 5. Moose population survey results for Unit 23, 1985-2001.

Area	Year	Month	# Moose obs.'ed	Total est.	80% c.i. (%)	90% c.i. (%)	95% c.i. (%)	Total Density (/sq. mi.)	Adult Density (/sq. mi.)	Est. # adults	Est. # Calves	B:100C	Ca:100C	Ca:100Ad	Census Area (mi2)	Area surveyed (mi2)	% of Census Area surveyed	
Squirrel	1992	November	346	1372	18	24	28	0.95	0.77	1110	262	37	33	24	1440.9	361.0	25	S
Squirrel	1998	November	345	1537	12	16	19	1.07	0.90	1304	233	50	27	18	1440.9	386.8	27	S
Noatak	1993	November	688	1125	12	16	19	0.69	0.59	956	169	43	25	18	1627.9	511.7	31	S
Noatak	1997	May	390											8	1627.9	578.8	36	M
Noatak	1998	May	454											12	1627.9	643.5	40	M
Noatak	1999	April/May	639	1191	19	24	29	0.56	0.53	1126	65			6	2111.2	462.0	22	S
Noatak	2000	May	364	779	15	19	22	0.37	0.34	710	59			8	2111.2	427	20	S
Noatak	2001	March	632	1453	14	18	21	0.69	0.63	1325	130			10	2111.2	572	27	S
Noatak	2001	March/April	709	1731	14	18	21	0.33	0.30	1580	151			10	5230.2	832	16	S
Salmon	1995	November	147	780	32	42	51	0.87	0.67	594	186	78	56	31	891.5	233.0	24	M
Salmon	1997	November	627	1023				1.15	1.00	895	129	60	23	14	891.5	396.6	33	S
Up. Kobuk	1995	November	340	815	19	24	28	0.57	0.51	730	85	62	19	12	1437.7	458.8	32	Li
Tagagawik	1997	March	840	1145	9	12	14	1.14	0.95	952	191			20	1000.9	462.7	46	S
Tagagawik	2001	March	1061	1374	8	10	13	0.76	0.70	1259	115			9	1692.6	524.1	31	S
Up. Selawik	1999	November	427	648	13	17	21	0.62	0.54	569	80	68	23	14	1045.9	512.4	49	S


2001 Noatak Moose Population Survey
March-April 2001
Figure 1. Core and Expanded survey areas.
Core Area
Expanded Area
Core Sample Units
Expanded Sample Units
Area Excluded
Map Location
National Park Service
Noatak National Preserve
Natural Resources
30 0 30 Kilometers
1 : 1,377,950 1 inch = 35.00 kilometers
N
W
E
S


2001 Noatak Moose Population Survey
March-April 2001
Survey Area
High Density
Low Density
Area Excluded
National Park Service
Noatak National Preserve
Natural Resources
25 0 25 50 Kilometers
1 : 1,440,292 1 inch = 36.58 kilometers

APPENDIX A.

A Spatial Moose Survey Estimation Method
Jay VerHoef, ADF&G, Fairbanks, Ak.

Introduction

This is an introduction to a spatial moose survey estimation method. The significant changes from previous moose survey methods are the sample unit layout design and the data analysis method. The spatial method uses newer technologies to greater advantage, including GPS (Global Positioning System), GIS (Geographic Information System), and a spatial statistics analysis method. It is hoped that this method will be easier to implement and more cost effective than previous methods.

Methods

Overview

The SPATIAL method involves five basic elements that 'include, 1) defining the survey area, 2) stratifying the area, 3) determining sample sizes, 4) surveying a random sample of units within the area, and 5) analyzing the data. Major changes from the traditional stratified random sample method (Gasaway et al.) are: the size of the survey area can be much larger, sample units have boundaries that are blocks delineated by latitude and longitude, elimination of the sightability correction factor plots, and the analysis utilizes ARCINFO (ERSI Redlands, Ca) GIS and a spatial statistics model. It is important to note that the survey data collected can still be analyzed using MOOSEPOP.

Sample Units

One of the major departures from earlier methods is the sample unit. Earlier methods defined sample units with borders based on landmarks including roads, trails, rivers, creeks, ridges, old firelines, and treelines. The spatial method utilizes GIS technology to layout the sample units. The north-south boundaries are based on even increments of latitude (2 minutes, starting at 0) and the east-west boundaries are based on increments of longitude (5 minutes, starting at 0). At approximately 65 degrees latitude sample unit size is approximately 5.5 square miles.

Area

The initial step in doing the spatial method is to identify the survey area. The size of the survey area can be quite large (one was 5000 mi^2). Identification of the survey area is enhanced using GIS technology. Sample units on a 2 degree latitude by 5 degree longitude grid, as described earlier, have been produced for the whole state of Alaska and the Yukon territory. Parts of this grid can be overlaid on 1:250,000 USGS topographic maps in a GIS. Then, by using the select feature from a GIS, the sample units to comprise a survey are easily selected. Finally, a database (or EXCEL file) of the sample units comprising the survey area is easily created.

Maps

Maps and data forms are need for stratification and sampling. Sample units are overlaid on a 1:250,000 scale USGS maps for navigation purposes, and on the back a bare outline of sample units is given that gives information on the latitude and longitude of each sample unit. The numbers listed below each sample unit are something like

6208-16220, which means that the southeast comer of that sample unit is at the coordinates 62 degrees, 08 minutes north latitude, and 162 degrees, 20 minutes west longitude. The copies were then laminated with plastic to make them durable for multiple use. Laminated maps can be written on with permanent markers (sharpie Brand) and then be wiped clean using isopropyl alcohol (rubbing) and a rag, and then reused to following day. Several sets of maps are produces so each survey crew can have a complete set to use during survey sampling.

Data Entry

All data, including stratification and actual counts, should be entered into the EXCEL files that are provided with the maps.

Stratification

The first step in conducting the survey is to complete the stratification. This involves flying transacts through the middle of each sample unit and classifying it to a relative moose density and habitat. Flying down the center of the sample unit allows about 50 units to be stratified per hour, and it is common to do about 250 sample units per day or about 1250 mi^2 per day, depending on day length and travel time to and from the survey area.

The next step in conducting the survey is to complete the stratification. This can be done in one of several ways. A flight may be taken just prior to a survey where local abundance of moose is established. This often allows 3 or 4 strata to be distinguished (e.g., very high, high, medium, and low abundance). This provides the most accurate stratification but may change rapidly, so it requires surveying the area immediately after stratification. This is a dynamic stratification.

Other ways to stratify are based on habitat and past experience. The sample units using the spatial technique are about one-half the size of those using the traditional Gasaway method, and hence movement can be a greater problem. So instead of trying to stratify where the moose are during the flight, groups of plots are considered together based on sightings, tracks, and habitat. Stratification then involves "painting with a broad brush" to classify groups of samples. This uses a combination of the number of observed moose, observed tracks, and the related habitat for stratifying. For example, even if you don't actually observe a moose (or many moose) in a sample unit, but others nearby of substantially the same habitat type do have moose, you should stratify it similarly as those nearby because it has a high probability of being used by moose at the time of the survey. This stratification is static, and can be used, with slight modification, year after year. The static stratification is less precise than the dynamic one. Because intimate knowledge of sample units is lacking, there are often only 2 strata (e.g., high and low). Also, because the stratification is static, sampling can occur over the course of several weeks rather than several days. Another possibility is a hybrid strategy where sample units that are clearly within a strata are initially determined, and then a quick flight with a fast airplane can be used to stratify sample units that are uncertain.

Personnel requirements in the airplane, excluding the pilot, are I navigator/notetaker, and 2 observers. Stratification can be done in many ways, including a concensus where, after each sample unit is passed over and the pilot calls out the new border, the Navigator/notetaker calls out a classification and the two observers either confer or rebut that classification. Alternatively, the navigator/notetaker can be responsible for making the call. It is also important to use local expert knowledge, previous stratifications, and any other sources of information to make the best stratification possible. It is also possible to stratify the area based only on previous information - without having to fly.

Stratifying can be done to as many levels as desired. However, if the stratification is being done from the office, and/or the same stratification will be used from year to year, then it will be difficult to stratify into anything more than low and high. The criteria for determining the breaks in stratification depend on the study area and they are relative. In general, try to get about 30-40 percent of the sample units classified as high, and 60-70 percent as low.

The main reason for stratification is to allocate sample units. It is desirable to isolate variability. In general, we need to sample a higher proportion of sample units with higher abundance of moose because they usually have higher variability.

Selecting Survey Samples

Once the stratification data have been entered, the EXCEL file should be sorted first by stratification, and then by the random order column. Sample units for the supercubs are then taken from the top of the list for each stratum. Usually, the total number is selected so that each supercub can have 12 sample units. After all sample units are identified for the day, they are grouped into areas so that supercubs can fly them efficiently and to minimize contact with other aircraft. In general, about 100 sample units should be flown in all, with no less than 25 in any strata. When the survey is nearly complete, about 10 sample units may be used nonrandomly to fill in any areas that were not sampled, or had light coverage, due to random sampling. This is important for the spatial statistics analytical method, which does not rely on the fact that the data are chosen as random.

Conducting the survey

Flying the sample units uses GPS technology. The latitude and longitude of the southeast comer of each sample unit was used to identify the sample units. Using a GPS and the rectangular sample units obviates the need for detailed maps. Several methods may be used to fly the sample units. One method is to fly transacts from one end of the sample unit to the other, and then move incrementally through the plot on each transect. This is efficient and works well in flat terrain. However, it is difficult in mountainous terrain. In mountainous terrain, it is more efficient to fly contours without paying close attention to the boundaries, only ensuring that all of the sample unit is covered. Then, if a moose is found near a border, the position can be recorded as a waypoint and the GPS can be used to decide whether it is in or out of the sample unit.

The samples should be flown at a rate of about 8 minutes per square mile, so it may take 30-50 minutes to do a sample unit. The rate can vary depending on the sightability and tracking conditions. If there is deep snow and it is more than several days old, and there are no tracks, then the time can be cut down somewhat if it is certain there are no moose. Likewise, if there is little vegetation so that sightability is excellent, then the time can be shortened. Conversely, if there is dense tree cover, samples should be flown at 12 minutes per square mile. In general, a supercub can do from 6 to 12 units per day depending on conditions and day length. If a supercub has 2 or 3 adjacent sample units, they can be flown concurrently. Whenever a moose is encountered, it can be simply determined which sample unit it belongs in by using the GPS.

Comparison to other methods

Stratified Random Sampling

The first widely-used statistically-based method for surveying moose was a stratified random sampling design (Gasaway et al., 1987). In this method, stratification was achieved by using 3 observers and a pilot in an airplane (such as a Cessna 185) that flew at about I 00 knots and surveyed at a rate of about I 00 ini2 per hour. Sample units were observed just prior to sampling to determine relative abundance of moose so that sample units could be stratified. After stratification, the sample units were flown as quickly as possible while the stratification was still good. Sample units were about 10- *1* 5 rni2 in size, and flown with small aircraft (such as a Piper SuperCub) at slow speed (about 70 mph) at about 4 minutes per square mile. After a sample unit had been flown, a smaller area within the sample unit, of about 2 rn@, was flown at an intensity of about 12 minutes per square mile to determine how many moose had been missed in the first sampling. This second, more intensive flight, provided the basis of a sightability correction factor (SCF) that adjusted the estimates upwards according to the proportion of moose that were missed during the initial sampling of a unit.

APPENDIX B.

Population Estimates

Spatial Estimate – Expanded, Spring Survey Area ($5,230\ mi^2$)

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[1] "TOTAL"
> "prediction column"
[1] "prediction column"
> column.pred
[1] "WHOLEAREA"
> fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 1731.264

$total.se:
         [,1]
[1,] 191.0335

$conf.int.80:
[1] 1486.444 1976.083

$ci.prop.mean.80:
          [,1]
[1,] 0.1414107

$conf.int.90:
[1] 1417.042 2045.486

$ci.prop.mean.90:
          [,1]
[1,] 0.1814987

$conf.int.95:
[1] 1356.845 2105.682

$ci.prop.mean.95:
         [,1]
[1,] 0.216269
```

Moosepop Estimate – Expanded, Spring Survey Area

```
$analysis.column:
[1] "TOTAL"

$total.estimate:
[1] 1730.335

$total.standard.error:
[1] 194.919
```

```
$sample.sizes:
  stratum sample.sizes
1       H           83
2       L           82

$total.samples:
  stratum sample.sizes
1       H          174
2       L          857

$moose.counted:
  stratum counted
1       H     680
2       L      29

$mean.density:
  stratum mean.density
1       H   1.62337662
2       L   0.07016967

$stratum.estimates:
  stratum total.estimate
1       H      1424.9237
2       L       305.4117

$stratum.variances:
  stratum total.variance
1       H       20859.46
2       L       17133.95

$sampled.area:
  stratum sampled.area
1       H      418.880
2       L      413.284

$total.area:
  stratum total.area
1       H    877.753
2       L   4352.475

$degrees.of.freedom:
[1] 161.6342

$confidence.interval.80.percent:
[1] 1479.511 1981.159

$conf.int.80.percent.proportion.of.mean:
[1] 0.1449568

$confidence.interval.90.percent:
[1] 1407.874 2052.797

$conf.int.90.percent.proportion.of.mean:
[1] 0.1863578

$confidence.interval.95.percent:
[1] 1345.419 2115.252

$conf.int.95.percent.proportion.of.mean:
[1] 0.2224518
```

Spatial Estimate – Core Area

```
[1] "analysis column"
> column.ana
[1] "TOTAL"
> "prediction column"
[1] "prediction column"
> column.pred
[1] "CORE"
> fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 1407.355

$total.se:
         [,1]
[1,] 132.9329

$conf.int.80:
[1] 1236.994 1577.715

$ci.prop.mean.80:
          [,1]
[1,] 0.1210501

$conf.int.90:
[1] 1188.70 1626.01

$ci.prop.mean.90:
          [,1]
[1,] 0.1553661

$conf.int.95:
[1] 1146.811 1667.898

$ci.prop.mean.95:
          [,1]
[1,] 0.1851301
```

Spatial Estimate – Expanded Area (3,119 mi^2)

```
> "analysis column"
[1] "analysis column"
> column.ana
[1] "TOTAL"
> "prediction column"
[1] "prediction column"
> column.pred
[1] "EXPANDED"
> fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 323.9089

$total.se:
         [,1]
[1,] 104.9098

$conf.int.80:
[1] 189.4616 458.3563
```

```
$ci.prop.mean.80:
          [,1]
[1,] 0.4150776

$conf.int.90:
[1] 151.3476 496.4703

$ci.prop.mean.90:
          [,1]
[1,] 0.5327464

$conf.int.95:
[1] 118.2895 529.5284

$ci.prop.mean.95:
          [,1]
[1,] 0.6348065
```

Composition

Spatial Estimate of Calf:Adult Ratio in Expanded, Spring Survey Area

```
> "prediction column"
[1] "prediction column"
> column.pred
[1] "WHOLEAREA"
> "numerator"
[1] "numerator"
> num.col.ana
[1] "CALF"
> num.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 150.8686

$total.se:
         [,1]
[1,] 27.97959

$conf.int.80:
[1] 115.0113 186.7259

$ci.prop.mean.80:
          [,1]
[1,] 0.2376723

$conf.int.90:
[1] 104.8463 196.8909

$ci.prop.mean.90:
          [,1]
[1,] 0.3050491

$conf.int.95:
[1]  96.0296 205.7076
```

```
$ci.prop.mean.95:
          [,1]
[1,] 0.3634884

> "denominator"
[1] "denominator"
> den.col.ana
[1] "ADULT"
> den.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 1579.685

$total.se:
         [,1]
[1,] 170.3902

$conf.int.80:
[1] 1361.321 1798.048

$ci.prop.mean.80:
          [,1]
[1,] 0.1382326

$conf.int.90:
[1] 1299.418 1859.952

$ci.prop.mean.90:
          [,1]
[1,] 0.1774196

$conf.int.95:
[1] 1245.726 1913.643

$ci.prop.mean.95:
          [,1]
[1,] 0.2114085

> "ratio"
[1] "ratio"
> krige.ratio.est
$ratio.estimate:
           [,1]
[1,] 0.09550552

$ratio.standard.error:
           [,1]
[1,] 0.02049004

$ratio.degrees.of.freedom:
[1] 165

$ratio.confidence.interval.80.percent:
[1] 0.06914091 0.12187012

$ratio.conf.int.80.percent.proportion.of.mean:
          [,1]
[1,] 0.2760532

$ratio.confidence.interval.90.percent:
[1] 0.0616121 0.1293989
```

```
$ratio.conf.int.90.percent.proportion.of.mean:
          [,1]
[1,] 0.3548844

$ratio.confidence.interval.95.percent:
[1] 0.05504904 0.13596199

$ratio.conf.int.95.percent.proportion.of.mean:
          [,1]
[1,] 0.4236035
```

Spatial Estimate of Calf:Adult Ratio in Core Area

```
> "prediction column"
[1] "prediction column"
> column.pred
[1] "CORE"
> "numerator"
[1] "numerator"
> num.col.ana
[1] "CALF"
> num.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 119.9907

$total.se:
         [,1]
[1,] 18.00296

$conf.int.80:
[1]  96.91899 143.06243

$ci.prop.mean.80:
          [,1]
[1,] 0.1922792

$conf.int.90:
[1]  90.37848 149.60294

$ci.prop.mean.90:
          [,1]
[1,] 0.2467877

$conf.int.95:
[1]  84.70556 155.27586

$ci.prop.mean.95:
          [,1]
[1,] 0.2940657

> "denominator"
[1] "denominator"
> den.col.ana
[1] "ADULT"
> den.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 1291.129

$total.se:
```

```
         [,1]
[1,] 122.2552

$conf.int.80:
[1] 1134.453 1447.806

$ci.prop.mean.80:
          [,1]
[1,] 0.1213483

$conf.int.90:
[1] 1090.037 1492.221

$ci.prop.mean.90:
          [,1]
[1,] 0.1557488

$conf.int.95:
[1] 1051.514 1530.745

$ci.prop.mean.95:
          [,1]
[1,] 0.1855862

> "ratio"
[1] "ratio"
> krige.ratio.est
$ratio.estimate:
          [,1]
[1,] 0.0929347

$ratio.standard.error:
          [,1]
[1,] 0.0164882

$ratio.degrees.of.freedom:
[1] 114

$ratio.confidence.interval.80.percent:
[1] 0.07168105 0.11418835

$ratio.conf.int.80.percent.proportion.of.mean:
          [,1]
[1,] 0.2286944

$ratio.confidence.interval.90.percent:
[1] 0.06559182 0.12027757

$ratio.conf.int.90.percent.proportion.of.mean:
         [,1]
[1,] 0.294216

$ratio.confidence.interval.95.percent:
[1] 0.0602717 0.1255977

$ratio.conf.int.95.percent.proportion.of.mean:
          [,1]
[1,] 0.3514618
```

Spatial Estimate of Calf:Adult Ratio in Expanded Area

```
> "prediction column"
[1] "prediction column"
> column.pred
[1] "EXPANDED"
> "numerator"
[1] "numerator"
> num.col.ana
[1] "CALF"
> num.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 30.87789

$total.se:
         [,1]
[1,] 16.27081

$conf.int.80:
[1] 10.02600 51.72977

$ci.prop.mean.80:
          [,1]
[1,] 0.6753015

$conf.int.90:
[1]  4.114784 57.640986

$ci.prop.mean.90:
          [,1]
[1,] 0.8667401

$conf.int.95:
[1]  -1.012316  62.768086

$ci.prop.mean.95:
         [,1]
[1,] 1.032785

> "denominator"
[1] "denominator"
> den.col.ana
[1] "ADULT"
> den.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 288.5553

$total.se:
         [,1]
[1,] 92.71747

$conf.int.80:
[1] 169.7331 407.3775

$ci.prop.mean.80:
          [,1]
[1,] 0.4117832
```

```
$conf.int.90:
[1] 136.0486 441.0620

$ci.prop.mean.90:
         [,1]
[1,] 0.528518

$conf.int.95:
[1] 106.8324 470.2782

$ci.prop.mean.95:
         [,1]
[1,] 0.629768

> "ratio"
[1] "ratio"
> krige.ratio.est
$ratio.estimate:
          [,1]
[1,] 0.1070086

$ratio.standard.error:
           [,1]
[1,] 0.06604347

$ratio.degrees.of.freedom:
[1] 51

$ratio.confidence.interval.80.percent:
[1] 0.02125951 0.19275759

$ratio.conf.int.80.percent.proportion.of.mean:
          [,1]
[1,] 0.8013289

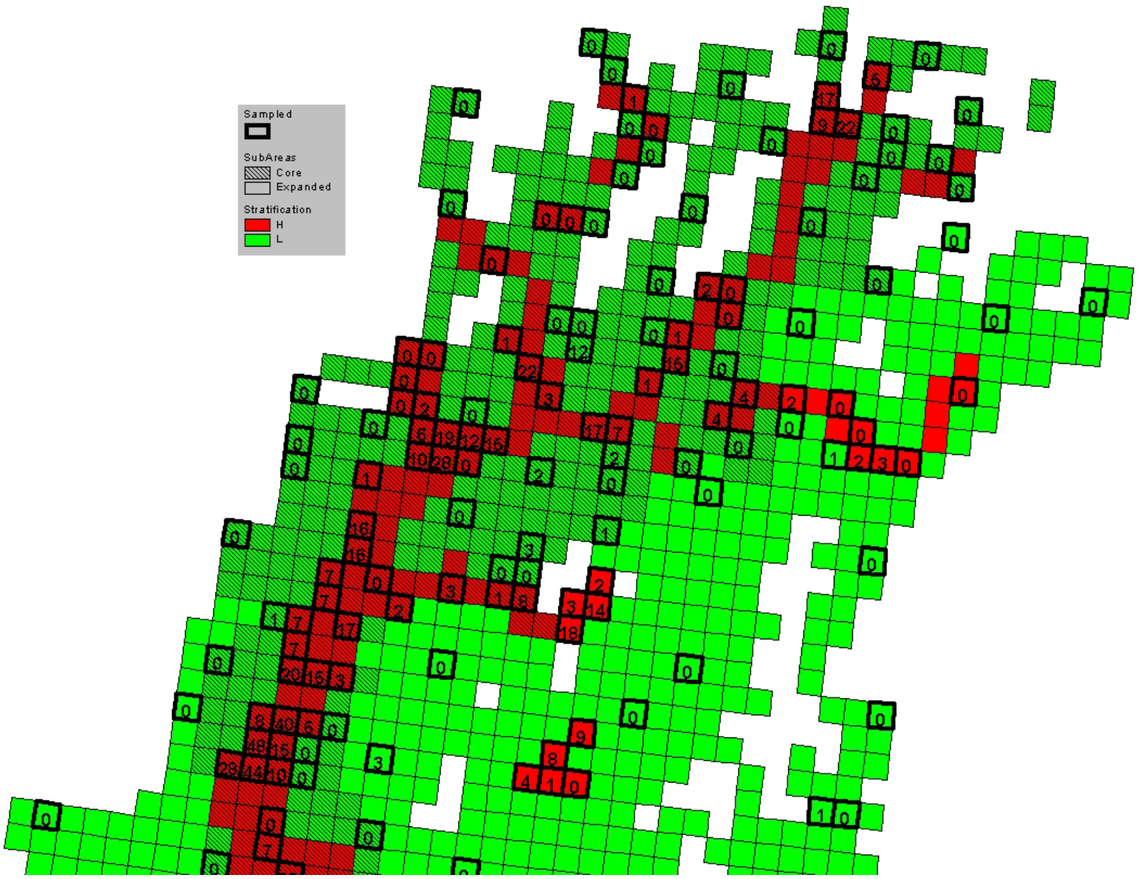
$ratio.confidence.interval.90.percent:
[1] -0.003633084  0.217650188

$ratio.conf.int.90.percent.proportion.of.mean:
         [,1]
[1,] 1.033951

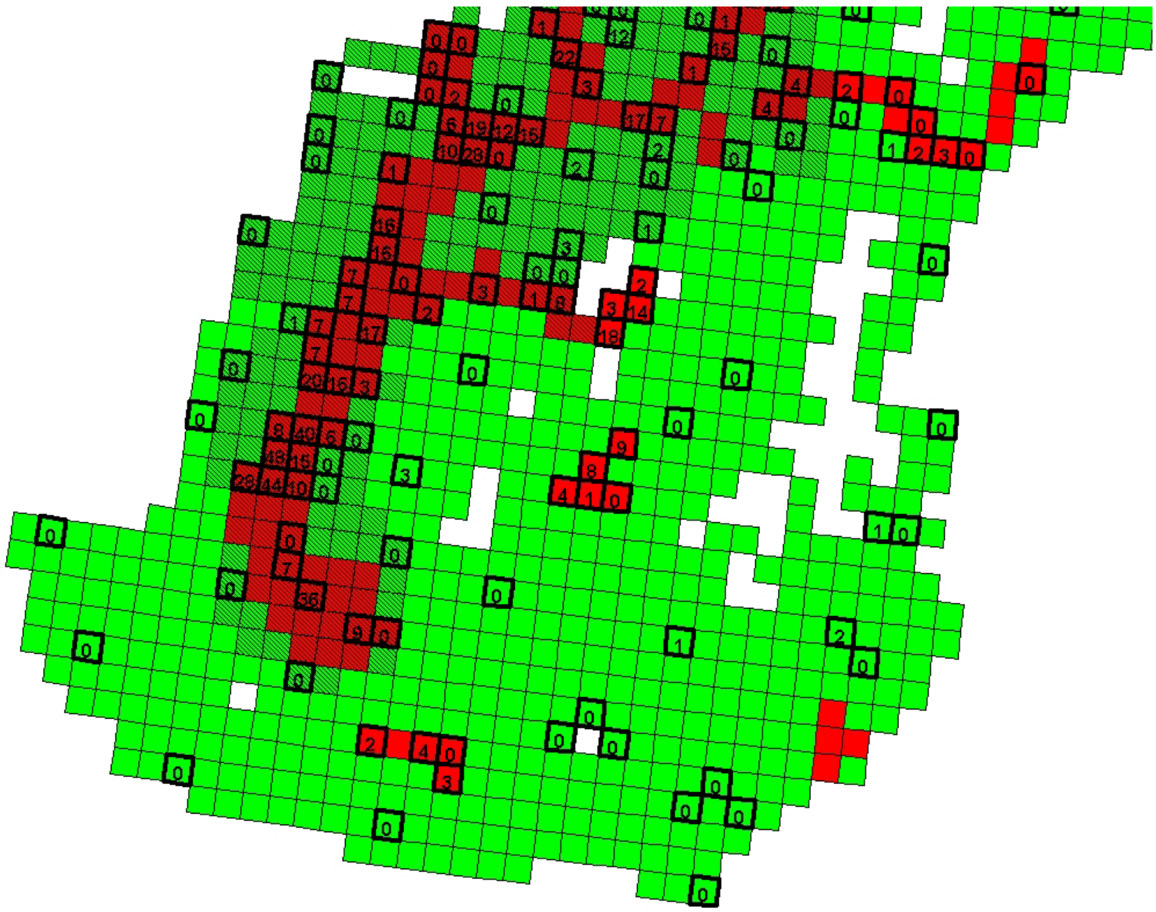
$ratio.confidence.interval.95.percent:
[1] -0.02557925  0.23959636

$ratio.conf.int.95.percent.proportion.of.mean:
         [,1]
[1,] 1.239039
```

Northern Part



Southern Part



Population Estimates

Spatial Estimate – Spring Survey Area

```
> "analysis column"
[1] "analysis column"
> column.ana
[1] "TOTAL"
> "prediction column"
[1] "prediction column"
> column.pred
[1] "bt"
> fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 1453.187

$total.se:
         [,1]
[1,] 156.7656

$conf.int.80:
[1] 1252.284 1654.090

$ci.prop.mean.80:
          [,1]
[1,] 0.1382501

$conf.int.90:
[1] 1195.331 1711.044

$ci.prop.mean.90:
         [,1]
[1,] 0.177442

$conf.int.95:
[1] 1145.932 1760.442

$ci.prop.mean.95:
          [,1]
[1,] 0.2114352
```

Moosepop Estimate - Total Area

```
$analysis.column:
[1] "TOTAL"

$total.estimate:
[1] 1488.041

$total.standard.error:
[1] 164.8889

$sample.sizes:
  stratum sample.sizes
1       H           63
2       L           51
```

```
$total.samples:
  stratum sample.sizes
1       H          143
2       L          278

$moose.counted:
  stratum counted
1       H     605
2       L      21

$mean.density:
  stratum mean.density
1       H   1.90677899
2       L   0.08237588

$stratum.estimates:
  stratum total.estimate
1       H      1373.4624
2       L       114.5785

$stratum.variances:
  stratum total.variance
1       H      23362.471
2       L       3825.872

$sampled.area:
  stratum sampled.area
1       H      317.289
2       L      254.929

$total.area:
  stratum total.area
1       H    720.305
2       L   1390.923

$degrees.of.freedom:
[1] 81.26668

$confidence.interval.80.percent:
[1] 1274.995 1701.087

$conf.int.80.percent.proportion.of.mean:
[1] 0.1431719

$confidence.interval.90.percent:
[1] 1213.695 1762.386

$conf.int.90.percent.proportion.of.mean:
[1] 0.1843669

$confidence.interval.95.percent:
[1] 1159.980 1816.102

$conf.int.95.percent.proportion.of.mean:
[1] 0.2204649
```

Spatial Estimate – 93 Autumn Survey Area Only (SU's marked with "F")

```
> "analysis column"
[1] "analysis column"
> column.ana
[1] "TOTAL"
> "prediction column"
[1] "prediction column"
> column.pred
[1] "fall"
> fin.pop.krige.out
$total.estimate:
        [,1]
[1,] 855.506

$total.se:
        [,1]
[1,] 130.215

$conf.int.80:
[1]  688.6287 1022.3833

$ci.prop.mean.80:
          [,1]
[1,] 0.1950627

$conf.int.90:
[1]  641.3213 1069.6907

$ci.prop.mean.90:
          [,1]
[1,] 0.2503602

$conf.int.95:
[1]  600.2892 1110.7228

$ci.prop.mean.95:
          [,1]
[1,] 0.2983226
```

Composition

Spatial Estimate of Calf:Adult Ratio in Spring Survey Area

```
> "prediction column"
[1] "prediction column"
> column.pred
[1] "bt"
> "numerator"
[1] "numerator"
> num.col.ana
[1] "CALF"
> num.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 130.4265

$total.se:
         [,1]
[1,] 21.79856

$conf.int.80:
[1] 102.4905 158.3625

$ci.prop.mean.80:
          [,1]
[1,] 0.2141895

$conf.int.90:
[1]  94.57102 166.28192

$ci.prop.mean.90:
          [,1]
[1,] 0.2749093

$conf.int.95:
[1]  87.70207 173.15087

$ci.prop.mean.95:
          [,1]
[1,] 0.3275746

> "denominator"
[1] "denominator"
> den.col.ana
[1] "ADULT"
> den.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 1324.976

$total.se:
         [,1]
[1,] 143.2808

$conf.int.80:
[1] 1141.355 1508.598
```

```
$ci.prop.mean.80:
          [,1]
[1,] 0.1385849

$conf.int.90:
[1] 1089.300 1560.652

$ci.prop.mean.90:
          [,1]
[1,] 0.1778718

$conf.int.95:
[1] 1044.151 1605.802

$ci.prop.mean.95:
          [,1]
[1,] 0.2119474

> "ratio"
[1] "ratio"
> krige.ratio.est
$ratio.estimate:
           [,1]
[1,] 0.09843683

$ratio.standard.error:
           [,1]
[1,] 0.01959544

$ratio.degrees.of.freedom:
[1] 114

$ratio.confidence.interval.80.percent:
[1] 0.07317787 0.12369579

$ratio.conf.int.80.percent.proportion.of.mean:
          [,1]
[1,] 0.2566007

$ratio.confidence.interval.90.percent:
[1] 0.06594112 0.13093254

$ratio.conf.int.90.percent.proportion.of.mean:
          [,1]
[1,] 0.3301174

$ratio.confidence.interval.95.percent:
[1] 0.0596184 0.1372553

$ratio.conf.int.95.percent.proportion.of.mean:
          [,1]
[1,] 0.3943486
```

Spatial Estimate of Calf:Adult Ratio, 93 Autumn Survey Area Only (SU's marked with "F")

```
> "prediction column"
[1] "prediction column"
> column.pred
```

```
[1] "fall"
> "numerator"
[1] "numerator"
> num.col.ana
[1] "CALF"
> num.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 60.53058

$total.se:
         [,1]
[1,] 18.10261

$conf.int.80:
[1] 37.33115 83.73001

$ci.prop.mean.80:
          [,1]
[1,] 0.3832679

$conf.int.90:
[1] 30.75444 90.30672

$ci.prop.mean.90:
         [,1]
[1,] 0.491919

$conf.int.95:
[1] 25.05012 96.01104

$ci.prop.mean.95:
          [,1]
[1,] 0.5861577

> "denominator"
[1] "denominator"
> den.col.ana
[1] "ADULT"
> den.fin.pop.krige.out
$total.estimate:
         [,1]
[1,] 802.4578

$total.se:
         [,1]
[1,] 118.6319

$conf.int.80:
[1] 650.4249 954.4906

$ci.prop.mean.80:
         [,1]
[1,] 0.189459

$conf.int.90:
[1] 607.3257 997.5898

$ci.prop.mean.90:
         [,1]
[1,] 0.243168

$conf.int.95:
```

```
[1]  569.9435 1034.9720

$ci.prop.mean.95:
          [,1]
[1,] 0.2897526

> "ratio"
[1] "ratio"
> krige.ratio.est
$ratio.estimate:
           [,1]
[1,] 0.07543148

$ratio.standard.error:
           [,1]
[1,] 0.02516469

$ratio.degrees.of.freedom:
[1] 91

$ratio.confidence.interval.80.percent:
[1] 0.04294578 0.10791718

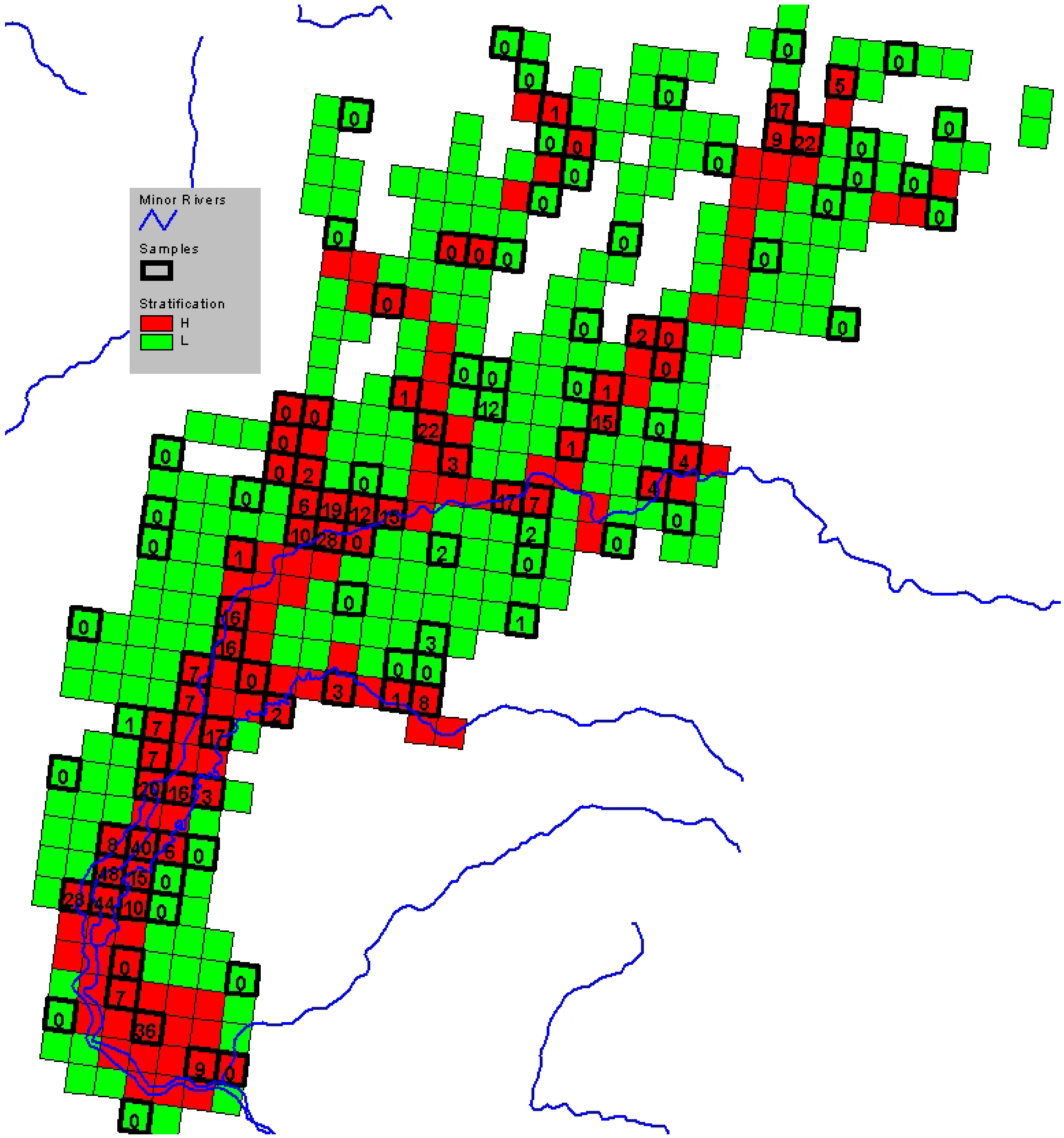
$ratio.conf.int.80.percent.proportion.of.mean:
         [,1]
[1,] 0.430665

$ratio.confidence.interval.90.percent:
[1] 0.03361352 0.11724944

$ratio.conf.int.90.percent.proportion.of.mean:
          [,1]
[1,] 0.5543833

$ratio.confidence.interval.95.percent:
[1] 0.02544492 0.12541805

$ratio.conf.int.95.percent.proportion.of.mean:
          [,1]
[1,] 0.6626751
```


Minor Rivers
Samples
Stratification
H
L